



ISU-003AX Seq

SEQUENCE LISTING

<110> Myers, Alan M.
James, Martha G.
<120> dull1 Coding for a Novel Starch Synthase and Uses
Thereof
<130> D6036PCT
<140> PCT/US98/24225
<141> 1998-11-12
<150> US 08/062,102
<151> 1997-11-12
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<210> 1
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<223> cDNA sequence corresponding to the gene encoding the
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<400> 1

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<210> 4
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<223> Primer_dul-sp4 used to amplify cloned BamHI fragment.
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site in the left arm in (gt11 phage DNA used to
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<223> (1356 primer located 281 bp distal to EcoRI cloning
site in the LacZ' region in the right arm in (gt11
phage DNA used to amplify cDNA inserts.
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<210> 8
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<223> Six residue M-box sequence in first half- repeat of ten
residue sequence of SBE-repeat in DU1.
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Asp Gln Ser Ile Val Gly
1 5

<210> 10
<211> 4
<212> PRT
<213> maize
<220>
<222> REPEAT
<223> Four residue sequence of second half-repeat of
ten residue SBE-repeat sequence in DU1.
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<212> PRT
<213> unknown
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<223> Deduced amino acid sequence of starch synthase DU1.
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Gly Pro Val Leu Ile Phe Arg Pro Thr Val Ala Gly Gly Gly Gly
20 25 30

Gly Thr Gln Ser Leu Leu Arg Thr Thr Arg Phe Ala Arg Arg Arg
35 40 45

Val Ile Arg Cys Val Val Ala Ser Pro Gly Cys Pro Asn Arg Lys
50 55 60

Ser Arg Thr Ala Ser Pro Asn Val Lys Val Ala Ala Tyr Ser Asn
65 70 75

Tyr Ala Pro Arg Leu Leu Val Glu Ser Ser Ser Lys Lys Ser Glu
80 85 90

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|-----------------|---------------------|-----------------|-------------|-----|-----|-----|
| His His Asp Ser | Ser Arg His Arg | Glu Glu Thr Ile | Asp Thr Tyr | 95 | 100 | 105 |
| Asn Gly Leu Ser | Gly Ser Asp Ala Ala | Glu Leu Thr Ser | Asn Arg | 110 | 115 | 120 |
| Asp Val Glu Ile | Glu Val Asp Leu Gln | His Ile Ser Glu | Glu Glu | 125 | 130 | 135 |
| Leu Pro Gly Lys | Val Ser Ile Asn Ala | Ser Leu Gly Glu | Met Glu | 140 | 145 | 150 |
| Thr Val Asp Glu | Ala Glu Val Glu Glu | Asp Lys Phe Glu | Val Asp | 155 | 160 | 165 |
| Thr Ser Gly Ile | Val Leu Arg Asn Val | Ala Val Arg Glu | Val Asp | 170 | 175 | 180 |
| Pro Lys Asp Glu | His Asn Ala Lys Asp | Val Phe Val Val | Asp Ser | 185 | 190 | 195 |
| Ser Gly Thr Ala | Pro Asp Asn Ala Ala | Val Glu Glu Val | Val Asp | 200 | 205 | 210 |
| Glu Ala Glu Val | Glu Glu Asp Met Val | Asp Val Asp Ile | Leu Gly | 215 | 220 | 225 |
| Leu Asp Leu Asn | Asn Ala Thr Ile Glu | Glu Ile Asp Leu | Met Glu | 230 | 235 | 240 |
| Glu Ala Leu Leu | Glu Asn Phe Asp Val | Asp Ser Pro Gly | Asn Ala | 245 | 250 | 255 |
| Ser Ser Gly Arg | Thr Tyr Gly Gly Val | Asp Glu Leu Gly | Glu Leu | 260 | 265 | 270 |
| Pro Ser Thr Ser | Val Asp Cys Ile Ala | Ile Asn Gly Lys | Arg Arg | 275 | 280 | 285 |
| Ser Leu Lys Pro | Lys Pro Leu Pro Ile | Val Arg Phe Gln | Glu Gln | 290 | 295 | 300 |
| Glu Gln Ile Val | Leu Ser Ile Val Asp | Glu Glu Gly Leu | Ile Ala | 305 | 310 | 315 |
| Ser Ser Cys Glu | Glu Gly Gln Pro Val | Val Asp Tyr Asp | Lys Gln | 320 | 325 | 330 |
| Glu Glu Asn Ser | Thr Ala Phe Asp Glu | Gln Lys Gln Leu | Thr Asp | 335 | 340 | 345 |
| Asp Phe Pro Glu | Glu Gly Ile Ser Ile | Val His Phe Pro | Glu Pro | 350 | 355 | 360 |
| Asn Asn Asp Ile | Val Gly Ser Ser Lys | Phe Leu Glu Gln | Lys Gln | 365 | 370 | 375 |
| Glu Leu Asp Gly | Ser Tyr Lys Gln Asp | Arg Ser Thr Thr | Gly Leu | 380 | 385 | 390 |
| His Glu Gln Asp | Gln Ser Val Val Ser | Ser His Gly Gln | Asp Lys | | | |

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| 395 | 400 | 405 |
|---|-----|-----|
| Ser Ile Val Gly Val Pro Gln Gln Ile Gln Tyr Asn Asp Gln Ser | 410 | 420 |
| Ile Ala Gly Ser His Arg Gln Asp Gln Ser Ile Ala Gly Ala Pro | 425 | 435 |
| Glu Gln Ile Gln Ser Val Ala Gly Tyr Ile Lys Pro Asn Gln Ser | 440 | 450 |
| Ile Val Gly Ser Cys Lys Gln His Glu Leu Ile Ile Pro Glu Pro | 455 | 465 |
| Lys Lys Ile Glu Ser Ile Ile Ser Tyr Asn Glu Ile Asp Gln Ser | 470 | 480 |
| Ile Val Gly Ser His Lys Gln Asp Lys Ser Val Val Ser Val Pro | 485 | 495 |
| Glu Gln Ile Gln Ser Ile Val Ser His Ser Lys Pro Asn Gln Ser | 500 | 510 |
| Thr Val Asp Ser Tyr Arg Gln Ala Glu Ser Ile Ile Gly Val Pro | 515 | 525 |
| Glu Lys Val Gln Ser Ile Thr Ser Tyr Asp Lys Leu Asp Gln Ser | 530 | 540 |
| Ile Val Gly Ser Leu Lys Gln Asp Glu Pro Ile Ile Ser Val Pro | 545 | 555 |
| Glu Lys Ile Gln Ser Ile Val His Tyr Thr Lys Pro Asn Gln Ser | 560 | 570 |
| Ile Val Gly Leu Pro Lys Gln Gln Gln Ser Ile Val His Ile Val | 575 | 585 |
| Glu Pro Lys Gln Ser Ile Asp Gly Phe Pro Lys Gln Asp Leu Ser | 590 | 600 |
| Ile Val Gly Ile Ser Asn Glu Phe Gln Thr Lys Gln Leu Ala Thr | 605 | 615 |
| Val Gly Thr His Asp Gly Leu Leu Met Lys Gly Val Glu Ala Lys | 620 | 630 |
| Glu Thr Ser Gln Lys Thr Glu Gly Asp Thr Leu Gln Ala Thr Phe | 635 | 645 |
| Asn Val Asp Asn Leu Ser Gln Lys Gln Glu Gly Leu Thr Lys Glu | 650 | 660 |
| Ala Asp Glu Ile Thr Ile Ile Glu Lys Ile Asn Asp Glu Asp Leu | 665 | 675 |
| Val Met Ile Glu Glu Gln Lys Ser Ile Ala Met Asn Glu Glu Gln | 680 | 690 |
| Thr Ile Val Thr Glu Glu Asp Ile Pro Met Ala Lys Val Glu Ile | 695 | 705 |
| Gly Ile Asp Lys Ala Lys Phe Leu His Leu Leu Ser Glu Glu Glu | | |

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|---------------|-----|-----|-----|------|-----|-----|-----|-----|------|-----|-----|-----|-----|------|
| 710 | | | | | 715 | | | | | 720 | | | | |
| Ser | Ser | Trp | Asp | Glu | Asn | Glu | Val | Gly | Ile | Ile | Glu | Ala | Asp | Glu |
| | | | | 725 | | | | | 730 | | | | | 735 |
| Gln | Tyr | Glu | Val | Asp | Glu | Thr | Ser | Met | Ser | Thr | Glu | Gln | Asp | Ile |
| | | | | 740 | | | | | 745 | | | | | 750 |
| Gln | Glu | Ser | Pro | Asn | Asp | Asp | Leu | Asp | Pro | Gln | Ala | Leu | Trp | Ser |
| | | | | 755 | | | | | 760 | | | | | 765 |
| Met | Leu | Gln | Glu | Leu | Ala | Glu | Lys | Asn | Tyr | Ser | Leu | Gly | Asn | Lys |
| | | | | 770 | | | | | 775 | | | | | 780 |
| Leu | Phe | Thr | Tyr | Pro | Asp | Val | Leu | Lys | Ala | Asp | Ser | Thr | Ile | Asp |
| | | | | 785 | | | | | 790 | | | | | 795 |
| Leu | Tyr | Phe | Asn | Arg | Asp | Leu | Ser | Ala | Val | Ala | Asn | Glu | Pro | Asp |
| | | | | 800 | | | | | 805 | | | | | 810 |
| Val | Leu | Ile | Lys | Gly | Ala | Phe | Asn | Gly | Trp | Lys | Trp | Arg | Phe | Phe |
| | | | | 815 | | | | | 820 | | | | | 825 |
| Thr | Glu | Lys | Leu | His | Lys | Ser | Glu | Leu | Ala | Gly | Asp | Trp | Trp | Cys |
| | | | | 830 | | | | | 835 | | | | | 840 |
| Cys | Lys | Leu | Tyr | Ile | Pro | Lys | Gln | Ala | Tyr | Arg | Met | Asp | Phe | Val |
| | | | | 845 | | | | | 850 | | | | | 855 |
| Phe | Phe | Asn | Gly | His | Thr | Val | Tyr | Glu | Asn | Asn | Asn | Asn | Asn | Asp |
| | | | | 860 | | | | | 865 | | | | | 870 |
| Phe | Val | Ile | Gln | Ile | Glu | Ser | Thr | Met | Asp | Glu | Asn | Leu | Phe | Glu |
| | | | | 875 | | | | | 880 | | | | | 885 |
| Asp | Phe | Leu | Ala | Glu | Glu | Lys | Gln | Arg | Glu | Leu | Glu | Asn | Leu | Ala |
| | | | | 890 | | | | | 895 | | | | | 900 |
| Asn | Glu | Glu | Ala | Glu | Arg | Arg | Arg | Gln | Thr | Asp | Glu | Gln | Arg | Arg |
| | | | | 905 | | | | | 910 | | | | | 915 |
| Met | Glu | Glu | Glu | Arg | Ala | Ala | Asp | Lys | Ala | Asp | Arg | Val | Gln | Ala |
| | | | | 920 | | | | | 925 | | | | | 930 |
| Lys | Val | Glu | Val | Glu | Thr | Lys | Lys | Asn | Lys | Leu | Cys | Asn | Val | Leu |
| | | | | 935 | | | | | 940 | | | | | 945 |
| Gly | Leu | Ala | Arg | Ala | Pro | Val | Asp | Asn | Leu | Trp | Tyr | Ile | Glu | Pro |
| | | | | 950 | | | | | 955 | | | | | 960 |
| Ile | Thr | Thr | Gly | Gln | Glu | Ala | Thr | Val | Arg | Leu | Tyr | Tyr | Asn | Ile |
| | | | | 965 | | | | | 970 | | | | | 975 |
| Asn | Ser | Arg | Pro | Leu | Val | His | Ser | Thr | Glu | Ile | Trp | Met | His | Gly |
| | | | | 980 | | | | | 985 | | | | | 990 |
| Gly | Tyr | Asn | Asn | Trp | Ile | Asp | Gly | Leu | Ser | Phe | Ala | Glu | Arg | Leu |
| | | | | 995 | | | | | 1000 | | | | | 1005 |
| Val | His | His | His | Asp | Lys | Asp | Cys | Asp | Trp | Trp | Phe | Ala | Asp | Val |
| | | | | 1010 | | | | | 1015 | | | | | 1020 |

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|---|-----------------------------|------|------|------|
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| Gly Pro Pro Gly Ser Ala Arg Asn Tyr Asp | Asn Asn Gly Gly His | 1040 | 1045 | 1050 |
| Asp Phe His Ala Thr Leu Pro Asn Asn Met Thr Glu Glu Glu Tyr | | 1055 | 1060 | 1065 |
| Trp Met Glu Glu Glu Gln Arg Ile Tyr Thr Arg Leu Gln Gln Glu | | 1070 | 1075 | 1080 |
| Arg Arg Glu Arg Glu Glu Ala Ile Lys Arg Lys Ala Glu Arg Asn | | 1085 | 1090 | 1095 |
| Ala Lys Met Lys Ala Glu Met Lys Glu Lys Thr Met Arg Met Phe | | 1100 | 1105 | 1110 |
| Leu Val Ser Gln Lys His Ile Val Tyr Thr Glu Pro Leu Glu Ile | | 1115 | 1120 | 1125 |
| His Ala Gly Thr Thr Ile Asp Val Leu Tyr Asn Pro Ser Asn Thr | | 1130 | 1135 | 1140 |
| Val Leu Thr Gly Lys Pro Glu Val Trp Phe Arg Cys Ser Phe Asn | | 1145 | 1150 | 1155 |
| Arg Trp Met Tyr Pro Gly Gly Val Leu Pro Pro Gln Lys Met Val | | 1160 | 1165 | 1170 |
| Gln Ala Glu Asn Gly Ser His Leu Lys Ala Thr Val Tyr Val Pro | | 1175 | 1180 | 1185 |
| Arg Asp Ala Tyr Met Met Asp Phe Val Phe Ser Glu Ser Glu Glu | | 1190 | 1195 | 1200 |
| Gly Gly Ile Tyr Asp Asn Arg Asn Gly Leu Asp Tyr His Ile Pro | | 1205 | 1210 | 1215 |
| Val Phe Gly Ser Ile Ala Lys Glu Pro Pro Met His Ile Val His | | 1220 | 1225 | 1230 |
| Ile Ala Val Glu Met Ala Pro Ile Ala Lys Val Gly Gly Leu Gly | | 1235 | 1240 | 1245 |
| Asp Val Val Thr Ser Leu Ser Arg Ala Val Gln Asp Leu Gly His | | 1250 | 1255 | 1260 |
| Asn Val Glu Val Ile Leu Pro Lys Tyr Gly Cys Leu Asn Leu Ser | | 1265 | 1270 | 1275 |
| Asn Val Lys Asn Leu Gln Ile His Gln Ser Phe Ser Trp Gly Gly | | 1280 | 1285 | 1290 |
| Ser Glu Ile Asn Val Trp Arg Gly Leu Val Glu Gly Leu Cys Val | | 1295 | 1300 | 1305 |
| Tyr Phe Leu Glu Pro Gln Asn Gly Met Phe Gly Val Gly Tyr Val | | 1310 | 1315 | 1320 |
| Tyr Gly Arg Asp Asp Asp Arg Arg Phe Gly Phe Phe Cys Arg Ser | | 1325 | 1330 | 1335 |

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Ala Leu Glu Phe Leu Leu Gln Ser Gly Ser Ser Pro Asn Ile Ile
 1340 1345 1350

His Cys His Asp Trp Ser Ser Ala Pro Val Ala Trp Leu His Lys
 1355 1360 1365

Glu Asn Tyr Ala Lys Ser Ser Leu Ala Asn Ala Arg Val Val Phe
 1370 1375 1380

Thr Ile His Asn Leu Glu Phe Gly Ala His His Ile Gly Lys Ala
 1385 1390 1395

Met Arg Tyr Cys Asp Lys Ala Thr Thr Val Ser Asn Thr Tyr Ser
 1400 1405 1410

Lys Glu Val Ser Gly His Gly Ala Ile Val Pro His Leu Gly Lys
 1415 1420 1425

Phe Tyr Gly Ile Leu Asn Gly Ile Asp Pro Asp Ile Trp Asp Pro
 1430 1435 1440

Tyr Asn Asp Asn Phe Ile Pro Val His Tyr Thr Cys Glu Asn Val
 1445 1450 1455

Val Glu Gly Lys Arg Ala Ala Lys Arg Ala Leu Gln Gln Lys Phe
 1460 1465 1470

Gly Leu Gln Gln Ile Asp Val Pro Val Val Gly Ile Val Thr Arg
 1475 1480 1485

Leu Thr Ala Gln Lys Gly Ile His Leu Ile Lys His Ala Ile His
 1490 1495 1500

Arg Thr Leu Glu Arg Asn Gly Gln Val Val Leu Leu Gly Ser Ala
 1505 1510 1515

Pro Asp Ser Arg Ile Gln Ala Asp Phe Val Asn Leu Ala Asn Thr
 1520 1525 1530

Leu His Gly Val Asn His Gly Gln Val Arg Leu Ser Leu Thr Tyr
 1535 1540 1545

Asp Glu Pro Leu Ser His Leu Ile Tyr Ala Gly Ser Asp Phe Ile
 1550 1555 1560

Leu Val Pro Ser Ile Phe Glu Pro Cys Gly Leu Thr Gln Leu Val
 1565 1570 1575

Ala Met Arg Tyr Gly Thr Ile Pro Ile Val Arg Lys Thr Gly Gly
 1580 1585 1590

Leu Phe Asp Thr Val Phe Asp Val Asp Asn Asp Lys Glu Arg Ala
 1595 1600 1605

Arg Asp Arg Gly Leu Glu Pro Asn Gly Phe Ser Phe Asp Gly Ala
 1610 1615 1620

Asp Ser Asn Gly Val Asp Tyr Ala Leu Asn Arg Ala Ile Ser Ala
 1625 1630 1635

Trp Phe Asp Ala Arg Ser Trp Phe His Ser Leu Cys Lys Arg Val
 1640 1645 1650

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Met Glu Gln Asp Trp Ser Trp Asn Arg Pro Ala Leu Asp Tyr Ile
1655 1660 1665

Glu Leu Tyr Arg Ser Ala Ser Lys Leu
1670

<210> 13
<211> 60
<212> PRT
<213> maize
<220>
<221> 418..477
<222> REPEAT
<223> First 60 amino acid residue SBE-superrepeat of 180
amino acid repeat residue in DU1.
<400> 13

Asp Gln Ser Ile Ala Gly Ser His Arg Gln Asp Gln Ser Ile Ala
1 5 10 15

Gly Ala Pro Glu Gln Ile Gln Ser Val Ala Gly Tyr Ile Lys Pro
20 25 30

Asn Gln Ser Ile Val Gly Ser Cys Lys Gln His Glu Leu Ile Ile
35 40 45

Pro Glu Pro Lys Lys Ile Glu Ser Ile Ile Ser Tyr Asn Glu Ile
50 55 60

<210> 14
<211> 60
<212> PRT
<213> maize
<220>
<221> REPEAT
<221> 478..537
<223> Second 60 amino acid residue SBE-superrepeat of 180
amino acid repeat residue in DU1.
<400> 14

Asp Gln Ser Ile Val Gly Ser His Lys Gln Asp Lys Ser Val Val
1 5 10 15

Ser Val Pro Glu Gln Ile Gln Ser Ile Val Ser His Ser Lys Pro
20 25 30

Asn Gln Ser Thr Val Pro Ser Tyr Arg Gln Ala Glu Ser Ile Ile
35 40 45

Gly Val Pro Glu Lys Val Gln Ser Ile Thr Ser Tyr Asp Lys Leu
50 55 60

<210> 15
<211> 60
<212> PRT
<213> maize
<220>
<221> REPEAT
<221> 438..597
<223> Third 60 amino acid residue SBE-superrepeat of 180
amino acid repeat residue in DU1.
<400> 15

Asp Gln Ser Ile Val Gly Ser Leu Lys Gln Asp Glu Pro Ile Ile
1 5 10 15

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Ser Val Pro Glu Lys Ile Gln Ser Ile Val His Tyr Thr Lys Pro
20 25 30

Asn Gln Ser Ile Val Gly Leu Pro Lys Gln Gln Gln Ser Ile Val
35 40 45

His Ile Val Glu Pro Lys Gln Ser Ile Asp Gly Phe Pro Lys Gln
50 55 60

<210> 16
<211> 10
<212> PRT
<213> maize
<220>
<221> 478..487
<222> REPEAT
<223> Sequence of SBE-repeat in DU1.
<400> 16

Asp Gln Ser Ile Val Gly Ser His Lys Gln
1 5 10

<210> 17
<211> 10
<212> PRT
<213> maize
<220>
<221> 538..547
<222> REPEAT
<223> Sequence of SBE-repeat in DU1.
<400> 17

Asp Gln Ser Ile Val Gly Ser Leu Lys Gln
1 5 10

<210> 18
<211> 10
<212> PRT
<213> maize
<220>
<221> 448.457
<222> REPEAT
<223> Sequence of SBE-repeat in DU1.
<400> 18

Asn Gln Ser Ile Val Gly Ser Cys Lys Gln
1 5 10

<210> 19
<211> 10
<212> PRT
<213> maize
<220>
<221> 568..577
<222> REPEAT
<223> Sequence of SBE-repeat in DU1.
<400> 19

Asn Gln Ser Ile Val Gly Leu Pro Lys Gln
1 5 10

<210> 20
<211> 10
<212> PRT
<213> maize
<220>
<221> 418..427
<222> REPEAT
<223> Sequence of SBE-repeat in DU1.
<400> 20

Asp Gln Ser Ile Ala Gly Ser His Arg Gln

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1          5          10
      <210> 21
      <211> 10
      <212> PRT
      <213> maize
      <220>
      <221> 428..437
      <222> REPEAT
      <223> Sequence of SBE-repeat in DU1.
      <400> 21
Asp Gln Ser Ile Ala Gly Ala Pro Glu Gln
1          5          10

      <210> 22
      <211> 10
      <212> PRT
      <213> maize
      <220>
      <221> 404..413
      <222> REPEAT
      <223> Sequence of SBE-repeat in DU1.
      <400> 22
Asp Lys Ser Ile Val Gly Val Pro Gln Gln
1          5          10

      <210> 23
      <211> 10
      <212> PRT
      <213> maize
      <220>
      <221> 598..607
      <222> REPEAT
      <223> Sequence of SBE-repeat in DU1.
      <400> 23
Asp Leu Ser Ile Val Gly Asn Glu Phe Gln
1          5          10

      <210> 24
      <211> 25
      <212> PRT
      <213> maize
      <220>
      <221> 529..553
      <222> REPEAT
      <223> Conserved M-box sequence in maize SBEI.
      <400> 24
Lys Cys Ile Ala Tyr Ala Glu Ser His Asp Gln Ser Ile Val Gly
1          5          10          15

Asp Lys Thr Ile Ala Phe Leu Leu Met Asp
          20          25

      <210> 25
      <211> 25
      <212> PRT
      <213> pea
      <220>
      <221> 529..553
      <222> REPEAT
      <223> Conserved M-box sequence in pea SBEII.
      <400> 25
Lys Cys Val Ser Tyr Ala Glu Ser His Asp Gln Ser Ile Val Gly
1          5          10          15

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Asp Lys Thr Ile Ala Phe Leu Leu Met Asp
      20                      25

<210> 26
<211> 25
<212> PRT
<213> wheat
<220>
<221> 529..553
<222> REPEAT
<223> Conserved M-box sequence in wheat SBEI.
<400> 26
Lys Cys Ile Ala Tyr Ala Glu Ser His Asp Gln Ser Ile Val Gly
  1      5      10      15

Asp Lys Thr Met Ala Phe Leu Leu Met Asp
      20                      25

<210> 27
<211> 25
<212> PRT
<213> maize
<220>
<221> 572..596
<222> REPEAT
<223> Conserved M-box sequence in maize SBEIa.
<400> 27
Lys Cys Val Thr Tyr Cys Glu Ser His Asp Gln Ala Leu Val Gly
  1      5      10      15

Asp Lys Thr Ile Ala Phe Trp Leu Met Asp
      20                      25

<210> 28
<211> 15
<212> PRT
<213> maize
<220>
<221> 572..596
<222> REPEAT
<223> Conserved M-box sequence in maize SBEIIb.
<400> 28
Lys Cys Val Thr Tyr Ala Glu Ser His Asp Gln Ala Leu Val Gly
  1      5      10      15

<210> 29
<211> 25
<212> PRT
<213> pea
<220>
<221> 572..596
<222> REPEAT
<223> Conserved M-box sequence in pea SBEI.
<400> 29
Lys Cys Val Val Tyr Cys Glu Ser His Asp Gln Ala Leu Val Gly
  1      5      10      15
Asp Lys Thr Met Ala Phe Leu Leu Met Asp
      20                      25

<210> 30
<211> 25
<212> PRT
<213> yeast

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<220>
<221> 477..501
<222> REPEAT
<223> Conserved M-box sequence in yeast GLC3 glycogen
        synthase.
<400> 30
Lys Val Val Ala Tyr Cys Glu Ser His Asp Gln Ala Leu Val Gly
 1      5      10      15
Asp Lys Ser Leu Ala Phe Trp Leu Met Asp
        20      25

<210> 31
<211> 25
<212> PRT
<213> Homo sapiens
<220>
<221> 477..501
<222> REPEAT
<223> Conserved M-box sequence in human liver glycogen
        synthase.
<400> 31
Lys Cys Ile Ala Tyr Ala Glu Ser His Asp Gln Ala Leu Val Gly
 1      5      10      15
Asp Lys Thr Leu Ala Phe Trp Leu Met Asp
        20      25

<210> 32
<211> 28
<212> PRT
<213> maize
<220>
<221> 150..177
<222> REPEAT
<223> Second 28 amino acid residue repeat of 85 residue
        repeat in N-terminus of DU1.
<400> 32
Glu Thr Val Asp Glu Ala Glu Val Glu Glu Asp Lys Phe Glu Val
 1      5      10      15
Asp Thr Ser Gly Ile Val Leu Arg Asn Val Ala Val Arg
        20      25

<210> 33
<211> 29
<212> PRT
<213> artificial sequence
<220>
<221> 178..205
<222> REPEAT
<223> Second 28 amino acid residue repeat of 85 residue
        repeat in N-terminus of DU1.
<400> 33
Glu Val Asp Pro Lys Asp Glu His Asn Ala Lys Asp Val Phe Val
 1      5      10      15
Val Asp Ser Ser Gly Thr Ala Pro Asp Asn Ala Ala Val Glu
        20      25

<210> 34
<211> 27
<212> PRT
<213> maize
<220>

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<221> 206..233

<222> REPEAT

<223> Third 28 amino acid residue repeat of 85 residue repeat in N-terminus of DU1.

<400> 34

| | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Glu | Val | Val | Asp | Glu | Ala | Glu | Val | Glu | Glu | Asp | Met | Val | Asp | Val |
| 1 | | | | 5 | | | | | 10 | | | | | 15 |

| | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Asp | Ile | Leu | Gly | Leu | Asp | Leu | Asn | Asn | Ala | Thr | Ile |
| | | | | 20 | | | | | 25 | | |

<210> 35

<211> 1230

<212> PRT

<213> potato

<220>

<223> Deduced amino acid sequence of potato starch synthase SSIII.

<400> 35

| | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Met | Asp | Val | Pro | Phe | Pro | Leu | His | Arg | Ser | Leu | Ser | Cys | Thr | Ser |
| 1 | | | | 5 | | | | | 10 | | | | | 15 |
| Val | Ser | Asn | Ala | Ile | Thr | His | Leu | Lys | Ile | Lys | Pro | Ile | Leu | Gly |
| | | | | 20 | | | | | 25 | | | | | 30 |

| | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Phe | Val | Ser | His | Gly | Thr | Thr | Ser | Leu | Ser | Val | Gln | Ser | Ser | Ser |
| | | | | 35 | | | | | 40 | | | | | 45 |

| | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Trp | Arg | Lys | Asp | Gly | Met | Val | Thr | Gly | Val | Ser | Phe | Ser | Ile | Cys |
| | | | | 50 | | | | | 55 | | | | | 60 |

| | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Ala | Asn | Phe | Ser | Gly | Arg | Arg | Arg | Arg | Lys | Val | Ser | Thr | Pro | Arg |
| | | | | 65 | | | | | 70 | | | | | 75 |

| | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Ser | Gln | Gly | Ser | Ser | Pro | Lys | Gly | Phe | Val | Pro | Arg | Lys | Pro | Ser |
| | | | | 80 | | | | | 85 | | | | | 90 |

| | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Gly | Met | Ser | Thr | Gln | Arg | Lys | Val | Gln | Lys | Ser | Asn | Gly | Asp | Lys |
| | | | | 95 | | | | | 100 | | | | | 105 |

| | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Glu | Ser | Lys | Ser | Thr | Ser | Thr | Ser | Lys | Glu | Ser | Glu | Ile | Ser | Asn |
| | | | | 110 | | | | | 115 | | | | | 120 |

| | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Gln | Lys | Thr | Val | Glu | Ala | Arg | Val | Glu | Thr | Ser | Asp | Asp | Asp | Thr |
| | | | | 125 | | | | | 130 | | | | | 135 |

| | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Lys | Gly | Val | Val | Arg | Asp | His | Lys | Phe | Leu | Glu | Asp | Glu | Asp | Glu |
| | | | | 140 | | | | | 145 | | | | | 150 |

| | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Ile | Asn | Gly | Ser | Thr | Lys | Ser | Ile | Ser | Met | Ser | Pro | Val | Arg | Val |
| | | | | 155 | | | | | 160 | | | | | 165 |

| | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Ser | Ser | Gln | Phe | Val | Glu | Ser | Glu | Glu | Thr | Gly | Gly | Asp | Asp | Lys |
| | | | | 170 | | | | | 175 | | | | | 180 |

| | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Asp | Ala | Val | Lys | Leu | Asn | Lys | Ser | Lys | Arg | Ser | Glu | Glu | Ser | Gly |
| | | | | 185 | | | | | 190 | | | | | 195 |

| | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Phe | Ile | Ile | Asp | Ser | Val | Ile | Arg | Glu | Gln | Ser | Gly | Ser | Gln | Gly |
| | | | | 200 | | | | | 205 | | | | | 210 |

| | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Glu | Thr | Asn | Ala | Ser | Ser | Lys | Gly | Ser | His | Ala | Val | Gly | Thr | Lys |
| | | | | 215 | | | | | 220 | | | | | 225 |

| | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Leu | Tyr | Glu | Ile | Leu | Gln | Val | Asp | Val | Glu | Pro | Gln | Gln | Leu | Lys |
| | | | | | | | | | | | | | | |

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| 230 | | | | 235 | | | | 240 | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Glu | Asn | Asn | Ala | Gly | Asn | Val | Glu | Tyr | Lys | Gly | Pro | Val | Ala | Ser |
| | | | | 245 | | | | | 250 | | | | | 255 |
| Lys | Leu | Leu | Glu | Ile | Thr | Lys | Ala | Ser | Asp | Val | Glu | His | Thr | Glu |
| | | | | 260 | | | | | 265 | | | | | 270 |
| Ser | Asn | Glu | Ile | Asp | Asp | Leu | Asp | Thr | Asn | Ser | Phe | Phe | Lys | Ser |
| | | | | 275 | | | | | 280 | | | | | 285 |
| Asp | Leu | Ile | Glu | Glu | Asp | Glu | Pro | Leu | Ala | Ala | Gly | Thr | Val | Glu |
| | | | | 290 | | | | | 295 | | | | | 300 |
| Thr | Gly | Asp | Ser | Ser | Leu | Asn | Leu | Arg | Leu | Glu | Met | Glu | Ala | Asn |
| | | | | 305 | | | | | 310 | | | | | 315 |
| Leu | Arg | Arg | Gln | Ala | Ile | Glu | Arg | Leu | Ala | Glu | Glu | Asn | Leu | Leu |
| | | | | 320 | | | | | 325 | | | | | 330 |
| Gln | Gly | Ile | Arg | Leu | Phe | Cys | Phe | Pro | Glu | Val | Val | Lys | Pro | Asp |
| | | | | 335 | | | | | 340 | | | | | 345 |
| Glu | Asp | Val | Glu | Ile | Phe | Leu | Asn | Arg | Gly | Leu | Ser | Thr | Leu | Lys |
| | | | | 350 | | | | | 355 | | | | | 360 |
| Asn | Glu | Ser | Asp | Val | Leu | Ile | Met | Gly | Ala | Phe | Asn | Glu | Trp | Arg |
| | | | | 365 | | | | | 370 | | | | | 375 |
| Tyr | Arg | Ser | Phe | Thr | Thr | Arg | Leu | Thr | Glu | Thr | His | Leu | Asn | Gly |
| | | | | 380 | | | | | 385 | | | | | 390 |
| Asp | Trp | Trp | Ser | Cys | Lys | Ile | His | Val | Pro | Lys | Glu | Ala | Tyr | Arg |
| | | | | 395 | | | | | 400 | | | | | 405 |
| Ala | Asp | Phe | Val | Phe | Phe | Asn | Gly | Gln | Asp | Val | Tyr | Asp | Asn | Asn |
| | | | | 410 | | | | | 415 | | | | | 420 |
| Asp | Gly | Asn | Asp | Phe | Ser | Ile | Thr | Val | Lys | Gly | Gly | Met | Gln | Ile |
| | | | | 425 | | | | | 430 | | | | | 435 |
| Ile | Asp | Phe | Glu | Asn | Phe | Leu | Leu | Glu | Glu | Lys | Trp | Arg | Glu | Gln |
| | | | | 440 | | | | | 445 | | | | | 450 |
| Glu | Lys | Leu | Ala | Lys | Glu | Gln | Ala | Glu | Arg | Glu | Arg | Leu | Ala | Glu |
| | | | | 455 | | | | | 460 | | | | | 465 |
| Glu | Gln | Arg | Arg | Ile | Glu | Ala | Glu | Lys | Ala | Glu | Ile | Glu | Ala | Asp |
| | | | | 470 | | | | | 475 | | | | | 480 |
| Arg | Ala | Gln | Ala | Lys | Glu | Glu | Ala | Ala | Lys | Lys | Lys | Lys | Val | Leu |
| | | | | 485 | | | | | 490 | | | | | 495 |
| Arg | Glu | Leu | Met | Val | Lys | Ala | Thr | Lys | Thr | Arg | Asp | Ile | Thr | Trp |
| | | | | 500 | | | | | 505 | | | | | 510 |
| Tyr | Ile | Glu | Pro | Ser | Glu | Phe | Lys | Cys | Glu | Asp | Lys | Val | Arg | Leu |
| | | | | 515 | | | | | 520 | | | | | 525 |
| Tyr | Tyr | Asn | Lys | Ser | Ser | Gly | Pro | Leu | Ser | His | Ala | Lys | Asp | Leu |
| | | | | 530 | | | | | 535 | | | | | 540 |
| Trp | Ile | His | Gly | Gly | Tyr | Asn | Asn | Trp | Lys | Asp | Gly | Leu | Ser | Ile |

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| 545 | 550 | 555 |
|-----------------|---|-----|
| Val Lys Lys Leu | Val Lys Ser Glu Arg Ile Asp Gly Asp Trp | Trp |
| 560 | 565 | 570 |
| Tyr Thr Glu Val | Val Ile Pro Asp Gln Ala Leu Phe Leu Asp | Trp |
| 575 | 580 | 585 |
| Val Phe Ala Asp | Gly Pro Pro Lys His Ala Ile Ala Tyr Asp | Asn |
| 590 | 595 | 600 |
| Asn His Arg Gln | Asp Phe His Ala Ile Val Pro Asn His Ile | Pro |
| 605 | 610 | 615 |
| Glu Glu Leu Tyr | Trp Val Glu Glu Glu His Gln Ile Phe Lys | Thr |
| 620 | 625 | 630 |
| Leu Gln Glu Glu | Arg Arg Leu Arg Glu Ala Ala Met Arg Ala | Lys |
| 635 | 640 | 645 |
| Val Glu Lys Thr | Ala Leu Leu Lys Thr Glu Thr Lys Glu Arg | Thr |
| 650 | 655 | 660 |
| Met Lys Ser Phe | Leu Leu Ser Gln Lys His Val Val Tyr Thr | Glu |
| 665 | 670 | 675 |
| Pro Leu Asp Ile | Gln Ala Gly Ser Ser Val Thr Val Tyr Tyr | Asn |
| 680 | 685 | 690 |
| Pro Ala Asn Thr | Val Leu Asn Gly Lys Pro Glu Ile Trp Phe | Arg |
| 695 | 700 | 705 |
| Cys Ser Phe Asn | Arg Trp Thr His Arg Leu Gly Pro Leu Pro | Pro |
| 710 | 715 | 720 |
| Gln Lys Met Ser | Pro Ala Glu Asn Gly Thr His Val Arg Ala | Thr |
| 725 | 730 | 735 |
| Val Lys Val Pro | Leu Asp Ala Tyr Met Met Asp Phe Val Phe | Ser |
| 740 | 745 | 750 |
| Glu Arg Glu Asp | Gly Gly Ile Phe Asp Asn Lys Ser Gly Met | Asp |
| 755 | 760 | 765 |
| Tyr His Ile Pro | Val Phe Gly Gly Val Ala Lys Glu Pro Pro | Met |
| 770 | 775 | 780 |
| His Ile Val His | Ile Ala Val Glu Met Ala Pro Ile Ala Lys | Val |
| 785 | 790 | 795 |
| Gly Gly Leu Gly | Asp Val Val Thr Ser Leu Ser Arg Ala Val | Gln |
| 800 | 805 | 810 |
| Asp Leu Asn His | Asn Val Asp Ile Ile Leu Pro Lys Tyr Asp | Cys |
| 815 | 820 | 825 |
| Leu Lys Met Asn | Asn Val Lys Asp Phe Arg Phe His Lys Asn | Tyr |
| 830 | 835 | 840 |
| Phe Trp Gly Gly | Thr Glu Ile Lys Val Trp Phe Gly Lys Val | Glu |
| 845 | 850 | 855 |

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| | | | | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|
| Gly | Leu | Ser | Val | Tyr | Phe | Leu | Glu | Pro | Gln | Asn | Gly | Leu | Phe | Ser | 860 | 865 | 870 |
| Lys | Gly | Cys | Val | Tyr | Gly | Cys | Ser | Asn | Asp | Gly | Glu | Arg | Phe | Gly | 875 | 880 | 885 |
| Phe | Phe | Cys | His | Ala | Ala | Leu | Glu | Phe | Leu | Leu | Gln | Gly | Gly | Phe | 890 | 895 | 900 |
| Ser | Pro | Asp | Ile | Ile | His | Cys | His | Asp | Trp | Ser | Ser | Ala | Pro | Val | 905 | 910 | 915 |
| Ala | Trp | Leu | Phe | Lys | Glu | Gln | Tyr | Thr | His | Tyr | Gly | Leu | Ser | Lys | 920 | 925 | 930 |
| Ser | Arg | Ile | Val | Phe | Thr | Ile | His | Asn | Leu | Glu | Phe | Gly | Ala | Asp | 935 | 940 | 945 |
| Leu | Ile | Gly | Arg | Ala | Met | Thr | Asn | Ala | Asp | Lys | Ala | Thr | Thr | Val | 950 | 955 | 960 |
| Ser | Pro | Thr | Tyr | Ser | Gln | Glu | Val | Ser | Gly | Asn | Pro | Val | Ile | Ala | 965 | 970 | 975 |
| Pro | His | Leu | His | Lys | Phe | His | Gly | Ile | Val | Asn | Gly | Ile | Asp | Pro | 980 | 985 | 990 |
| Asp | Ile | Trp | Asp | Pro | Leu | Asn | Asp | Lys | Phe | Ile | Pro | Ile | Pro | Tyr | 995 | 1000 | 1005 |
| Thr | Ser | Glu | Asn | Val | Val | Glu | Gly | Lys | Thr | Ala | Ala | Lys | Glu | Ala | 1010 | 1015 | 1020 |
| Leu | Gln | Arg | Lys | Leu | Gly | Leu | Lys | Gln | Ala | Asp | Leu | Pro | Leu | Val | 1025 | 1030 | 1035 |
| Gly | Ile | Ile | Thr | Arg | Leu | Thr | His | Gln | Lys | Gly | Ile | His | Leu | Ile | 1040 | 1045 | 1050 |
| Lys | His | Ala | Ile | Trp | Arg | Thr | Leu | Glu | Arg | Asn | Gly | Gln | Val | Val | 1055 | 1060 | 1065 |
| Leu | Leu | Gly | Ser | Ala | Pro | Asp | Pro | Arg | Val | Gln | Asn | Asn | Phe | Val | 1070 | 1075 | 1080 |
| Asn | Leu | Ala | Asn | Gln | Leu | His | Ser | Lys | Tyr | Asn | Asp | Arg | Ala | Arg | 1085 | 1090 | 1095 |
| Leu | Cys | Leu | Thr | Tyr | Asp | Glu | Pro | Leu | Ser | His | Leu | Ile | Tyr | Ala | 1100 | 1105 | 1110 |
| Gly | Ala | Asp | Phe | Ile | Leu | Val | Pro | Ser | Ile | Phe | Glu | Pro | Cys | Gly | 1115 | 1120 | 1125 |
| Leu | Thr | Gln | Leu | Thr | Ala | Met | Arg | Tyr | Gly | Ser | Ile | Pro | Val | Val | 1130 | 1135 | 1140 |
| Arg | Lys | Thr | Gly | Gly | Leu | Tyr | Asp | Thr | Val | Phe | Asp | Val | Asp | His | 1145 | 1150 | 1155 |
| Asp | Lys | Glu | Arg | Ala | Gln | Gln | Cys | Gly | Leu | Glu | Pro | Asn | Gly | Phe | 1160 | 1165 | 1170 |

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| | | | | | | | | | | | | | | |
|-----|-----|-----|------|-----|-----|-----|-----|-----|------|-----|-----|-----|-----|------|
| Ser | Phe | Asp | Gly | Ala | Asp | Ala | Gly | Gly | Val | Asp | Tyr | Ala | Leu | Asn |
| | | | 1175 | | | | | | 1180 | | | | | 1185 |
| Arg | Ala | Leu | Ser | Ala | Trp | Tyr | Asp | Gly | Arg | Asp | Trp | Phe | Asn | Ser |
| | | | 1190 | | | | | | 1195 | | | | | 1200 |
| Leu | Cys | Lys | Gln | Val | Met | Glu | Gln | Asp | Trp | Ser | Trp | Asn | Arg | Pro |
| | | | 1205 | | | | | | 1210 | | | | | 1215 |
| Ala | Leu | Asp | Tyr | Leu | Glu | Leu | Tyr | His | Ala | Ala | Arg | Lys | Leu | Glu |
| | | | 1220 | | | | | | 1225 | | | | | 1230 |

<210> 36
 <211> 9
 <212> DNA
 <213> artificial sequence
 <220>
 <222> repeat unit
 <223> Sequence of the nine base pair direct repeats flanking
 a Mul element in cloned fragment.
 <400> 36

gtgagaatg 9

<210> 37
 <211> 32
 <212> DNA
 <213> artificial sequence
 <221> primer
 <223> Primer containing restriction sites
 <400> 37

aaacccgggaattcgatggagatgggtcctacg

32